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Speech

by

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It is a distinct pleasure for me to be here to talk to you this afternoon to discuss a little about the management of large programs in advanced technology as we handle them in NASA, and about NASA organization and its objectives.

This, of course, is difficult to cover so much in such a short time so it will be a very brief sketch and will give you a "feeling" about the subject but will not be complete in any way.

First -- our objectives. For the next two decades, NASA is pursuing six major objectives:

<u>First</u>. We will continue to explore throughout the Solar System with automated spacecraft (that is, unmanned spacecraft); and one of the main aims of this exploration will be to find evidence of extra-terrestrial life, or at least a better understanding of how life arose on Earth.

<u>Second</u>. We will intensify our use of spacecraft in Earth orbit. Some of these spacecraft will look back at Earth and some will study the Sun or look far out into the Universe. Some will seek scientific information, some will produce more immediate practical benefits.

<u>Third</u>. During the remainder of this decade we will concentrate much of our effort on developing the Space Shuttle transportation system, which is a better and cheaper way of getting both manned and automated payloads to Earth orbit and back. We will also be working closely with ESRO on development of the manned Spacelab module to be carried to orbit and back in the Space Shuttle.

<u>Fourth</u>. In addition to developing the Space Shuttle in this decade, we are planning and developing the improved payloads for the Shuttle to launch and service in the 1980s and 1990s. These payloads will include large automated observatories and a wide range of experiments and practical tasks to be performed in the manned Spacelab module.

<u>Fifth</u>. We also have a number of programs to demonstrate how new technology developed in the space program can be used to meet national needs outside the aerospace field. For example, we already know a great deal about how solar energy can be harnessed or how hydrogen can be used as a fuel; and we hope our specialized knowledge of these and other energy-related fields can be utilized to help find long-range solutions to current energy shortages.

<u>Sixth</u>. We want to continue and expand international cooperation in space. Intensified space cooperation promotes the cause of world peace. But it can also serve other important mutual interests of the countries that cooperate.

I know at present you are primarily interested in practical applications of space technology. So are we. But we are committed to planetary exploration as the great intellectual adventure of our time; and we expect the new knowledge we get from the planets to be of much more practical significance than you may think.

Our automated spacecraft have already explored five planets: Mercury, Venus, Mars, Jupiter, -- and Earth. They have also explored four moons -- Earth's, Phobos, Deimos, near Mars, and just recently Io, near Jupiter.

In recent months, Mariner 10 has sent back the first close-up pictures of the cloud cover of Venus and the first detailed pictures of the surface of Mercury. Mariner 10 is now on its way around the Sun and will pass close to Mercury again in September.

We have been very pleased with the performance of the two Pioneer spacecraft we have sent to explore the giant planet Jupiter and beyond.

Pioneer 10 passed close to Jupiter in December of last year and sent back excellent color pictures and other data of great scientific interest. Pioneer 10 is now on its way out of the Solar System, and we will continue to communicate with it well out beyond the orbit of Uranus.

Meanwhile, Pioneer 11 is approaching Jupiter. It will pass Jupiter at close range in December, and draw on Jupiter's gravity to head for a close encounter with Saturn, too. We have not yet decided whether to pass close to Saturn, under its visible rings, or to pass more conservatively at a larger distance.

More difficult missions to explore the Outer Planets are tentatively planned for the next two decades. For example, we may put spacecraft into orbit around one of the moons of Jupiter in the early 1990's, and send a TV camera and other instruments to land on the surface of this Jovian moon.

Moving along to discuss "organization", as you may know, NASA was established by Act of Congress on October 1, 1958. Congress felt very strongly that one agency, headed by an Administrator, should be given the principal responsibility for government funded space activities except, of course, for military space activity. As a young organization we had behind us the heritage of the National Advisory Committee on Aeronautics, which had been formed in 1915 to do all of the Government research in aeronautics.

NASA is what we call an "independent agency." This means that we are not a part of one of the large traditional departments of government such as Commerce, Defense, or Transportation. This was done because NASA's space activities affect the whole spectrum of American life in many ways. As the head of an independent agency, the Administrator of NASA reports directly to the President.

The space programs and priorities of the United States, as recommended to Congress by the President, are what the President wants them to be. He has to keep in mind not only what he and his Administration want but what the country wants and what the Congress is willing to pay for.

Another facet of NASA's organization is the network of research and development centers and other facilities we have spread across the country.

These installations, and especially the people who work there, have become national resources of great value and high productivity. NASA has about 25,000 civil service personnel. Only some six percent of them are at NASA Headquarters. More than 40 percent of NASA's civil service personnel are scientists or engineers. About 15 percent are administrative professionals.

There are two conflicting approaches to the question of how a country like the United States, with a strong free enterprise tradition, should get its government-sponsored research and development work done. Do we do it in government laboratories and workshops manned by civil service personnel? Or do we contract it out to private industry?

NASA's approach is to contract with industry for as much research and development as industry is able to do -- with this one exception. We want to do enough R&D work within NASA to give us the personnel and the inside knowledge and the direct experience that is absolutely necessary if we are to plan our future programs wisely and effectively manage and supervise the work done under contract. I will have more to say about this later.

If we try to do too much R&D work inside NASA with government employees, we lose initiative and efficiency; if we do too little within NASA we are at the mercy of the industrial contractors when they tell us what can and cannot be done, or what costs should be and cannot make real time decisions during serious emergencies in flight.

For example, if you have to negotiate with a contractor to do a special bricklaying job, it would be helpful to you if you knew something about bricklaying, and more helpful still if you had had recent experience in the newest and best techniques for the special kind of job.

I want to emphasize that we work very closely with our contractors. It is essential that there be mutual respect and understanding and open channels of communication between the NASA people who award and manage the contracts and the industry people who carry them out.

We have to have highly qualified professional people in NASA who are recognized as outstanding by their industry colleagues. And as an organization that prides itself on good management, NASA has to know when to leave our contractors alone and when to step in and help them straighten out problems they may not themselves recognize or acknowledge. It is difficult to write a textbook on such matters. It is something you learn by experience. And that is why we have to keep a strong team of highly qualified and experienced personnel inside NASA. We also recognize the importance of an exchange of personnel between NASA and industry. This is sometimes criticized as leading to possible conflicts of interest. Again, it is a matter of how it is handled. We find that such exchanges, especially those involving high-level personnel, strengthen management in both NASA and industry. So our organization consists of an Administrator who works closely with the President and the Congress, the technical staff which manages the program, and industry which builds and tests the hardware. Industrial personnel total to about 100,000 people or about 80% of the total.

Back in the early days of the Space Age there was considerable speculation about whether a democratic country like the United States, with a free enterprise economy, could compete effectively with the Soviet Union in such large scientific and technological undertakings as the exploration of space.

We have met that challenge quite well. But we had to invent NASA to do it. Seriously, the first major scientific problem we had to solve in the Space Age was a problem in political science. We had to set up new government institutions and government approaches that would get the job done and still take advantage of the efficiency of the free enterprise system. We had to do that somewhat earlier in the atomic energy field. We had to do it again in space.

The third aspect you asked about is NASA's management methods.

Let me say to this audience that the pre-conditions to good management, like organization and clear objectives, have to be set by Governments and Parliaments. I believe I could say that if <u>you</u> do <u>your</u> job well, the managers will do <u>theirs</u> well.

At no point in the Apollo program did we try to hide behind security or any other measure. In fact, we conducted the program completely openly. Our successes, our failures, and everything we did was measured and was observed as we went along.

Some of the simple rules we live by are: design it to be simple, reduce the interfaces, build in redundancy, and test over and over again.

NASA had the responsibility and the authority to manage Apollo, but the bulk of the work on the program was carried out by American industry under NASA supervision. The role of NASA was, first of all, to formulate the overall design of the mission and the hardware. The decision to use something that wound up looking like the Saturn 5 launch vehicle and the command and service module and the lunar module and to use the lunar orbit rendezvous mode -- all of those things were decided by NASA.

The selections of industrial firms were made in response to solicitations, where we set out some fairly detailed technical specifications, and we selected to the best of our ability that firm that could meet the technical requirements for each job, hopefully within schedule and hopefully at the cost that we thought it should cost.

NASA also provided the overall specifications for each element of hardware once the contract was written. These were generally overall deployment type specifications. We did provide detailed specifications, of course, for the interface, where two major portions of the hardware (called subsystems) mated and came together.

The next job was to supervise and monitor the hardware contractors, and this is where I believe NASA's civil service capability, NASA's own technical capability with our own people and within our own facilities, and using test programs we could run in our own organization, came in.

We managed our contractors entirely with technical people. Each of those who had a role in the Apollo management at the level where contractors were managed had a technical background and had learned how to manage schedules, how to manage accounts and how to do these other things, and most of that was learned as we went along.

Hardware contractors were supervised and monitored. We conducted, in parallel with the contractors and in conjunction with them, an in-house test program, and I will have more to say about that in a moment.

It was NASA's job also to plan and conduct the flight operations and to train and select the astronauts that flew on the missions. Their training took place primarily at the Manned Spacecraft Center in Houston and also at the Kennedy Space Center at Cape Canaveral.

The role of industry was to design each element of hardware, and to make or buy the subsystems. In most cases, the subsystems in the spacecraft were bought by the major spacecraft contractors -- the life support systems, the couches, the instruments, the electrical power system. All of these things in the spacecraft were subcontracts to the prime contractors. There were a few exceptions. In the launch vehicle, the engine was so-called "Government-furnished equipment". In the spacecraft, NASA decided to make the guidance system, mainly for reasons of history, a piece of Government-furnished equipment. In other words, the Government held the contract with the guidance system contractor and that contractor was termed an associate rather than a subcontractor to Rockwell International who was the prime contractor.

Now, the design question is one we always face in this business. There were discussions about what the role of man should be and what should the machine do. The users, the pilots and the flight controllers are all involved in making those decisions because if they are not satisfied, they are not going to be able to properly fly the machine. We needed, of course, a fairly high level computer technology, and we let the man do what he <u>could</u> do and could do best: primarily to decide between redundant systems, using one as a backup. We let the machines and the computers do the repetitive, tedious tasks as much as possible.

Interfaces between separate modules, separate stages, separate elements were minimized. This was most important if this very complex job, that was spread all over our country, was to be accomplished. For example, we only had 100 tiny wires running back and forth between the spacecraft and its launch vehicle. We needed the 100 mostly because we had a very complicated emergency detection system, so that a booster malfunction would allow the spacecraft to abort. That means that one man at all times could be fully familiar with an interface, and really <u>only</u> one man. That means if you made a change on either side of the interface you could go to that one man and say, "Does it affect anything across the interface?" And immediately he would tell you that it would not, but in an hour he could tell you <u>definitely</u> not. If we had ten times as many wires across that interface, we probably would have needed 100 times as many people to work that interface and the job would have been far more complex.

As to hardware development, there are four areas particularly worth mentioning: The first one is design, the second one is test, the third is the understanding of failures, and the fourth is the control of changes.

As far as design is concerned, we tried to use the best combination of aircraft and missile practice and technology. One could summarize it with just one sentence: Build it simple and then double up as many components as possible to get the required redundancy. As far as building it simple is concerned, we selected for the spacecraft rocket engines with ablative chambers and ablative nozzles, so that we did not have to go to cooled engines. We used propellants that ignite spontaneously on contact so we did not have to develop ignition systems. We also selected for the spacecraft, pressure-fed systems so we did not have to go to pumps and high-pressure systems.

You have to assume that your designs are good to start with. But there are bound to be changes. Changes that just have to be made, and many other changes of varying degrees of desirability.

As far as redundancy is concerned, we used the three fuel cells, for example, for electrical power generation in the command and service modules, where only one was needed to bring us back safely from the Moon.

We used, throughout most of the plumbing and electrical systems, series-parallel redundancy, so that no open or closed failure of a circuit or a valve would cause the overall subsystem to fail, and we used this throughout almost everything in the spacecraft.

Then came the test program, which is generally considered the most single important factor leading to the success of Apollo. We tested and retested.

Our test program was started with the piece parts. We tested piece parts. We built the test program up into parts, components, subsystems, and systems, and each of those had to pass very well-defined and prescribed tests. The test of the piece part was much more severe than the test of the whole subsystem, which in turn was still more severe than the test of the spacecraft as a whole.

In this test program the Government-industry team started early working very, very hard and working together completely as a single team. There was joint agreement on the test conditions, and these conditions involved vibration and temperature, stress and vacuum, and all the other things that could be done on the ground to simulate as much as possible those things that would happen in space.

The tests then were performed generally by the industry under NASA's control, either at their own facilities or in NASA's.

Results were submitted to NASA, and we had to approve them, and we worked with industry especially closely on the results of tests when there was a failure.

Another management technique that works quite well is the use of Management Review Centers. At Cape Canaveral, for example, we have a big room where the progress on all major portions of launch preparations is displayed on big charts and reviewed weekly by the Center Director with his staff. If a certain NASA group, or a certain contractor group falls behind in its assigned task, it shows up there on the big board. You can imagine how the representative of Company X feels when he comes into the Management Review Center some fine morning and finds a little red light lit up on the big board after his company's name. The peer pressures, the professional pressures, the money pressures in such cases are tremendous. Nobody needs to scold anybody. Of course, it is not always that easy. Somebody still has to know when to turn the red light on. But if you are properly organized, you don't have to feel inhibited about turning on the light when the situation requires it.

The red light I speak of is a figure of speech. The marking on the board in the Management Review Center is a little more subtle. But Company X gets the message just as if red lights were flashing and bells were ringing.

Besides these rather formal check points, we had informal discussions on both sides and there was, undoubtedly, a kind of mutual trust.

In summing up, the point I hope I have conveyed is that attention to detail and strong Civil Service technical capability is really the heart of the management process.

It is fairly easy, with today's technology, to program a spacecraft to do certain things automatically. Where we are making real advances, I think, is in developing our abilities to react to the unexpected -- we call it "real time" mission planning.

The ability of the first Skylab crew to rig a sunshade saved our huge investment in Skylab. Sixty-three seconds after lift-off of the unmanned Skylab cluster, the Orbital Workshop meteoroid shield malfunctioned and was ripped away, thus throwing out of balance the thermal protection system. If the condition had been allowed to continue, the rapid temperature rise would have damaged film, food, and medicines. NASA and industry personnel worked together on this crisis and devised the idea of a parasol to act as a makeshift sunshade. In the next 10 days 3 different sunshades were designed and built on the ground and then one deployed in space by a crew who, though they had never seen it before, were able to deploy it in record time by simply following instructions sent up by the ground crew. As a bonus, the crew was able to cut loose from its metal trappings, using simple pruning shears, a large solar array which gave ample power for the remainder of the 272-day mission.

During the flight of Mariner 10 to Venus and Mercury, several problems occurred which threatened to either degrade spacecraft performance, compromise science data gathering sequences, or terminate the mission prematurely. Perhaps the most distressing of these was an oscillation in the spacecraft roll axis when the gyros were on. This caused the use of an excessive amount of attitude control nitrogen gas and an unexplained increase in spacecraft power usage. This would have caused us to abort the mission just before Venus encounter by either using up all the gas before Mercury encounter or to allow the spacecraft to tumble continuously because of "no roll" stabilization.

After much discussion and discarding of alternate possibilities and a great deal of computer analysis, we concluded that the way to solve this problem was to control the roll attitude not with nitrogen gas jets, but amazingly enough by using the so-called "solar wind" that consists of large amounts of high energy particles traveling rapidly through space to give enough torque to the spacecraft when needed. The way it worked was that we used the large solar panels which were used to collect energy from the Sun and by rotating them differentially, we were able to get the desired torque to keep the spacecraft on course. In fact, as we got closer to the Sun, the solar wind increased in intensity and helped us in this regard, especially as we approached the planet Mercury. I believe this is the first time "solar sailing" has ever been used in space, and may be a technique that we could use extensively in the future.

Perhaps the most remarkable thing about this solution was not its novelty, but rather that a solution of this sort could be worked out in such a brief period of time -- a matter of days rather than months or years.

A very recent demonstration of our ability to do "real time" mission planning occurred during the launch of SMS-1, the weather satellite we launched to geostationary orbit in May. We intended it for geostationary orbit but, due to a launch vehicle failure, it ended up short of the required altitude. Instead of taking up a position over the Equator where it could maintain a continuous weather watch over the United States and surrounding seas, it was moving rapidly into a position that would make it essentially worthless - a piece of space junk. But our engineers quickly diagnosed the problem, made some complicated calculations, and decided they could reach geostationary orbit by prolonged firing of the small thruster rockets that were supposed to be used only for station keeping of the spacecraft in the years ahead. It worked, and SMS-1 is now assured of being a valuable weather forecasting station for several years to come.

Now that NASA is primarily concerned with the exploration of the Solar System and development of the Space Shuttle and productive payloads for it, we have recently reorganized NASA Headquarters to reflect the changes in NASA programs and Headquarters-Center relations.

I think we have been very fortunate in the way NASA was originally set up and subsequently expanded. We have the institutional strength and the size to handle any national assignment in space and to encourage international cooperation.

I noted in my earlier remarks that one of our principal objectives is continuing cooperation with other nations in space programs of mutual interest. The principal product of that interest, combined with your own, is the agreement which we now have with the 9 member states of the European Space Research Organization, under which you will now develop and produce a Spacelab for use with our reusable Shuttle. This is an unprecedented cooperative enterprise which represents a most generous contribution by the European nations to the basic space facility of the 1980's, one which we can use in common on either a cooperative or reimbursable basis as circumstances warrant. This confidence in European space technology is well justified since most of the management techniques have already been implemented in many earlier joint programs by ESRO.

We also have an extensive list of efforts with the Soviet Union, the principal one of which is the Apollo-Soyuz Test Project.

Cooperative efforts extend into virtually all aspects of our own space program: the analysis of lunar samples, the design and implementation of experiments using earth resources data, the formulation of near-earth and planetary spacecraft missions, communications experiments, and so forth.

In the entire area of international cooperation, the principles of management which are the main thrust of my remarks apply fully as importantly as in our domestic programs. You have special problems of management which arise from the fact that you are integrating the efforts of a dozen countries. Thus, we can learn a good deal from each other in the field of management through international programs which offer values of their own.